ENERGY VADEMECUM

Things to know to be able to talk about them.

DEFINITIONS

PRINCIPLES

CONSEQUENCES

Know the difference between :
- power [kW] and energy [kWh].
- primary energy to be harvested and secondary vectors produced.

Respect the principles of thermodynamics:
equilibrium, conservation, disorder (entropy), absolute zero.

Primary energy harvesting must produce more energy than it costs! EROEI >> 1

The capacity factor describes the average utilisation rate of a facility.

The capacity factor of an installation dependent on a first one can only be lower.

To be stored, the electricity must be transformed.

Nothing is exponential, everything is finite.

Any process is never 100% efficient.

Embedded in any system, and in any proportion, so-called renewable energies
- do not meet demand at all times,
- reduce the efficiency of power generation,
- increase costs,
- multiply capital requirements,
- destabilise the grid,
- impose a larger environmental footprint.

Facts are stubborn.

Except for life, nothing is renewable.

Progress goes in one direction, towards a better use of resources and not their dilution, dispersion and wastage.

Energy supply must meet demand, not the other way around.

Recycling consumes, has diminishing returns and therefore has its limits.

Any economic or environmental assessment must be made between comparable systems that provide the same service.

Trade-offs are necessary,
based on reason and free of nonsense.

The production of coal- and gas-fired power stations in Germany is a cover-up for "renewables" whose congenital defects must be shamefully concealed.

No country is wealthy enough to afford a "whatever it takes".

No change without energy

High potential

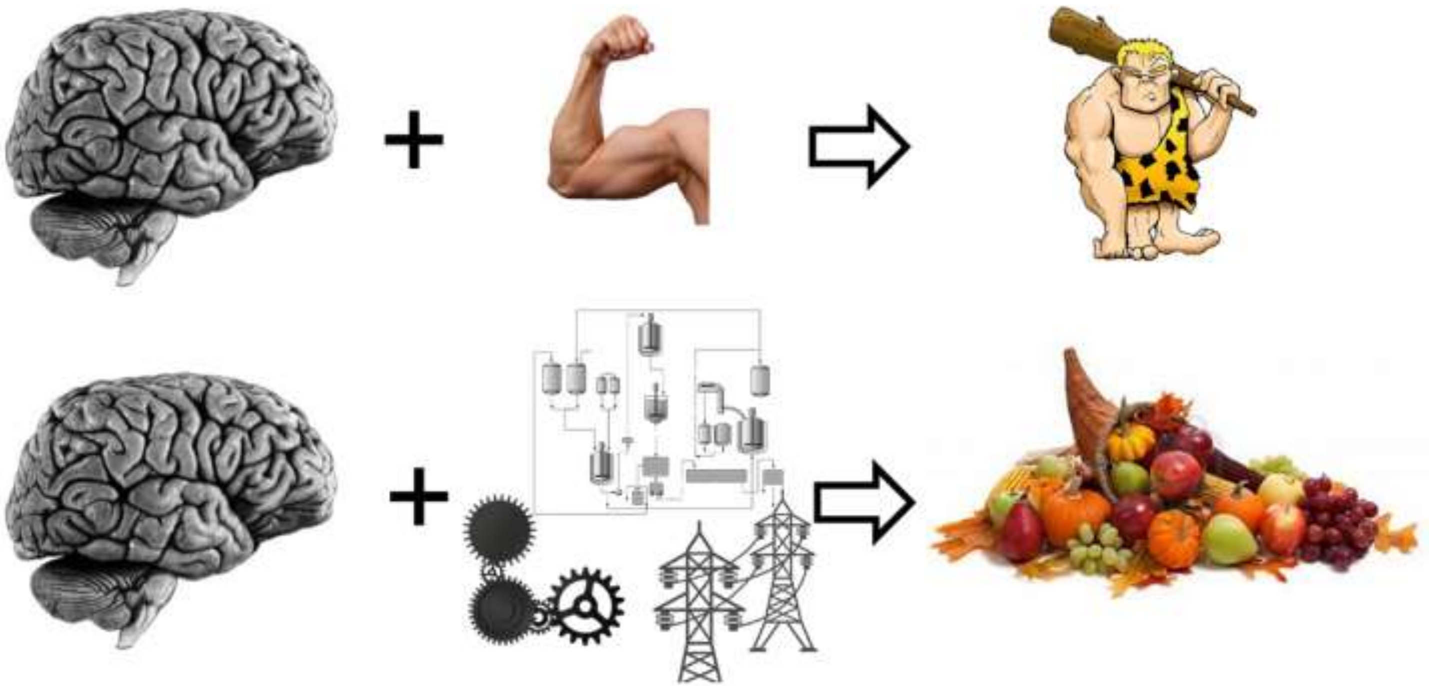
kinetics

Low potential

No prosperity without energy

BEFORE

NOW



Capacity to act?

N **newton**
X distance
J **joule**
÷ time
W **watt**

Force

The ability to perform or endure a physical physical, intellectual or moral action.

Exerted in a field, e.g., of gravity or potential.

$$Force = mass \times acceleration$$

$$1\,N = 1\,kg \times 1\,\frac{m}{s^2} = 1\,\frac{kg \cdot m}{s^2}$$

Energy

A force in action, physical or moral.

The ability of a body or system to produce work, i.e. a change of state.
For example, the ability to move an object in a field of gravity (force · distance).

$$1\,J = 1\,N \cdot m$$

$$1\,kWh = 1000\,W \times 3600\,s = 3\,600\,000\,J$$

Power

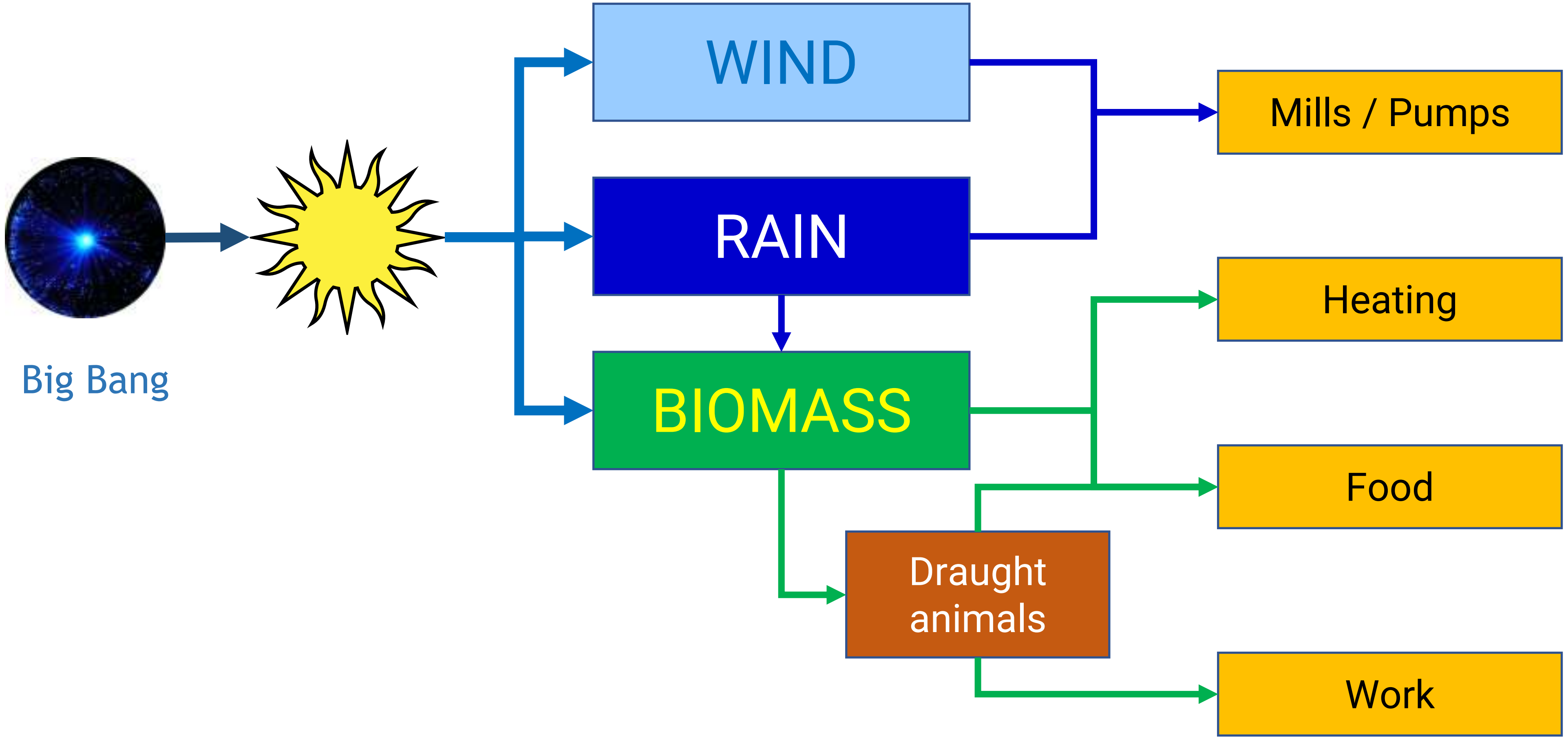
A power possessed by one being, group or entity to impose its authority, its domination on another.

Amount of work done in a unit of time, or energy released from one system or transferred from one system to another over this time.

$$1\,W = 1\,\frac{J}{s}$$

$$1\,CV = \frac{75\,kg \times 9.81\,\frac{m}{s^2} \times 1\,m}{1\,s} = 736\,W$$

Origins



Big Bang
WIND
RAIN
BIOMASS
Draught animals
Mills / Pumps
Heating
Food
Work

What Energy ?

- **Potential energy**: Energy that a body possesses due to its position (relative to a reference).

  As long as the apple had not fallen from the tree, it had potential energy.

- **Kinetic energy**: Energy that a body possesses as a result of its movement.

  When the apple hit Isaac Newton's skull, it released its kinetic energy.

- **Primary energy**: Natural form of energy available at a given place and time.

  Examples: solar irradiation (and its derivatives wind and rain), geothermal flow, coal, oil or gas deposits, uranium mine, biomass.

- **Secondary energy**: A form of energy obtained from a primary or another secondary energy. Energy carrier.

  Examples: electricity, refined fuels, water pumped at altitude, electrochemical energy in a battery, hydrogen or other synthetic fuels.

Energy management

- **Fatal energy**: Primary energy whose availability does not depend on human action.

  Examples: Solar radiation, wind, precipitation, geothermal, biomass.

- **Intermittent energy**: Primary energy whose availability is not controllable.

  Predictability is partial and the only way to manage it is to forego harvesting it, partially or completely.

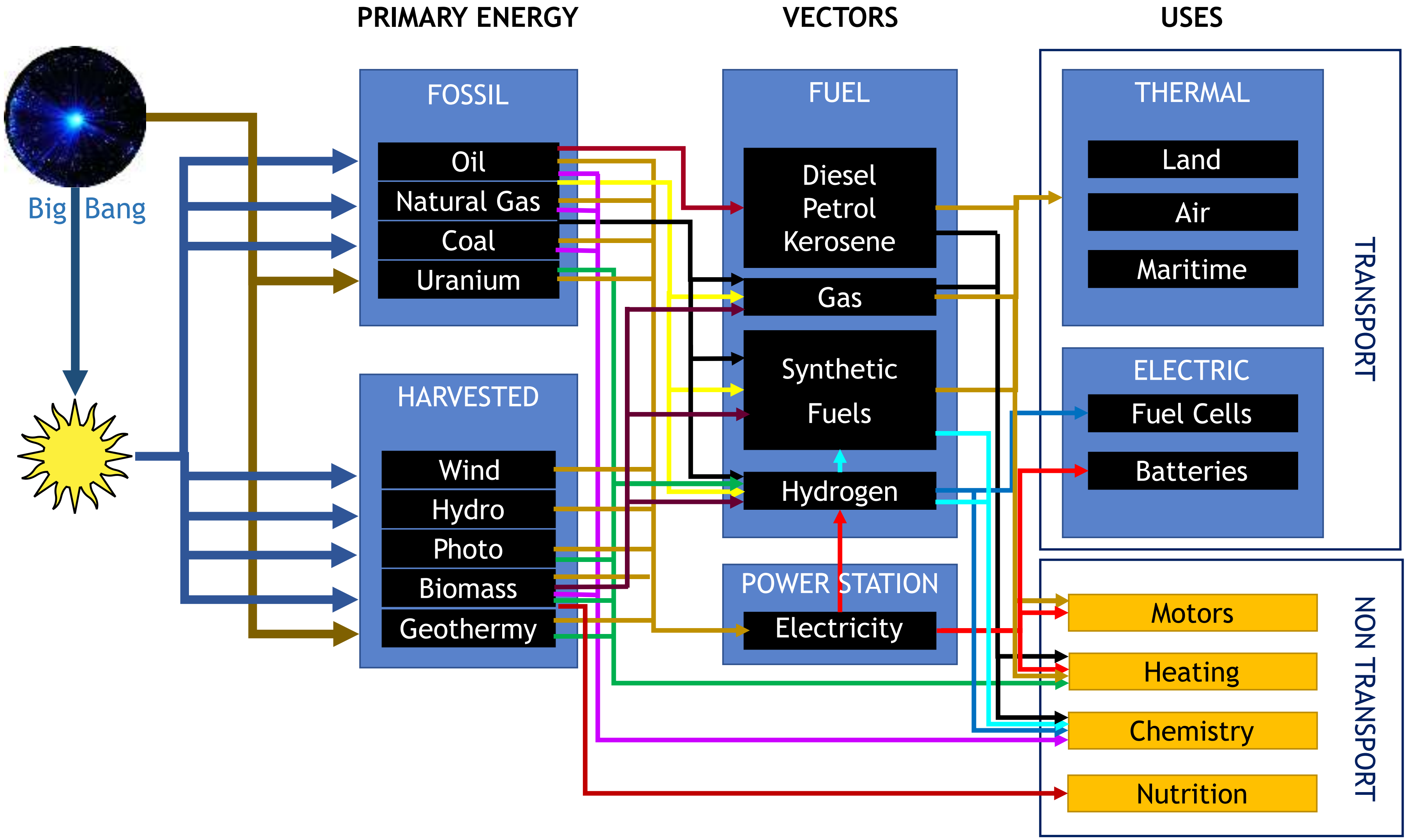
  Examples: PV, wind, run-of-river hydro which cannot be stored either.

- **Pilotable energy**: Primary or secondary energy whose availability can be modulated as desired.

  Examples: Electricity from
  - Gas, oil, coal or biomass power plants,
  - Hydroelectric storage power stations (in case of sufficient reserves),
  - Nuclear power plants (only to a limited extent),
  - Geothermal power plants and heat pumps.

Electricity requiring primary energy

Energy sources, vectors and uses



MR's Blog

Thermal – Heat

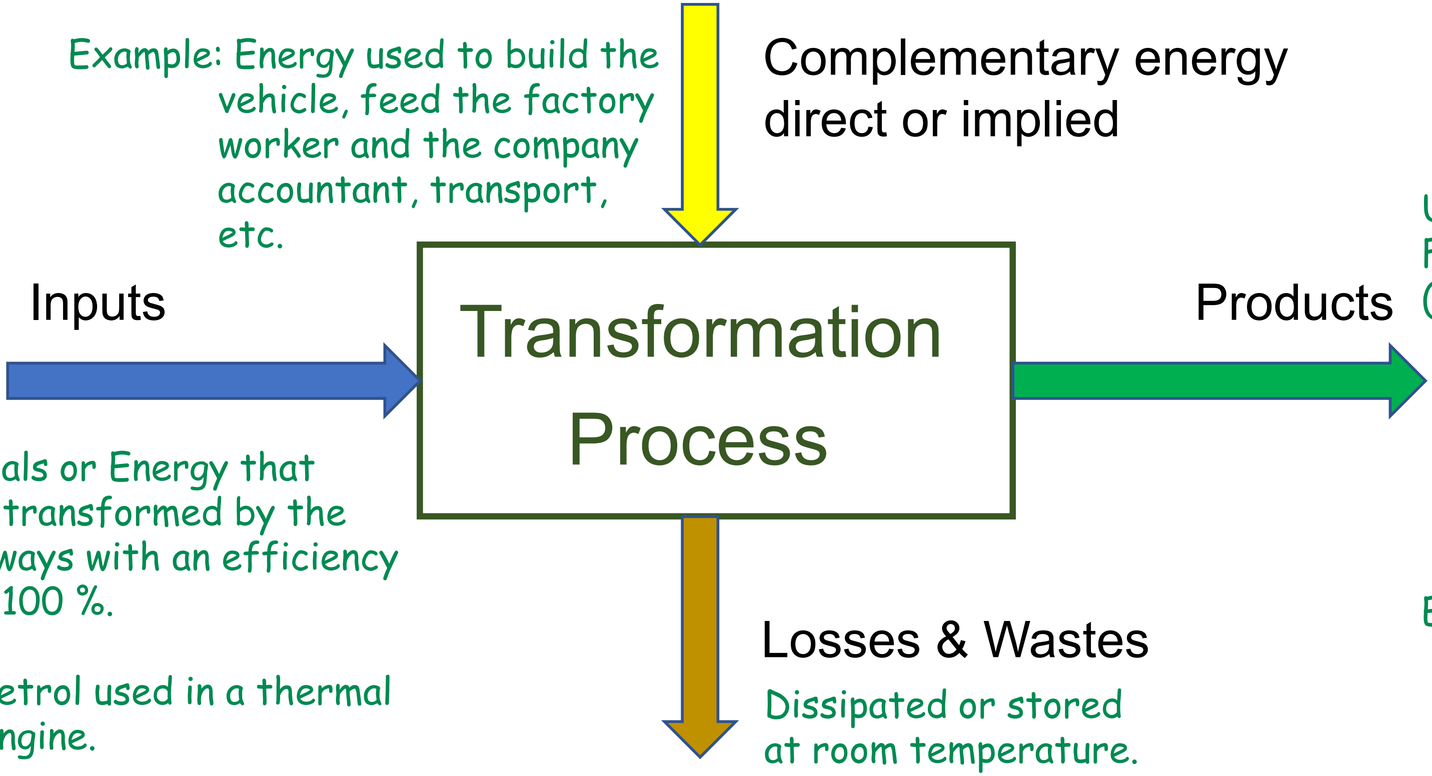
- **Temperature**: Physical quantity characterising the degree of thermal agitation of the particles forming a material. It is intensive because it does not depend on the size of the system.
- **Heat capacity**: The amount of heat energy that a mass or volume of matter can store.
  Heat that must be supplied to increase its temperature by one degree, expressed at constant pressure C_p [$J \cdot kg^{-1} \cdot K^{-1}$] or
  at constant volume, C_v [$J \cdot m^{-3} \cdot K^{-1}$].
- **Latent heat**: The heat supplied to change the state of a material, e.g., to melt or vaporise it , or the heat given off during the opposite phenomenon, crystallisation or condensation, [$J \cdot kg^{-1}$].
- **Heat of combustion**: Heat released by a fuel during combustion, characteristic of each flammable substance, [$J \cdot kg^{-1}$].
  The heat of evaporation of water produced during combustion must be taken into account (gross or net calorific value).

Human trickery to transform something

Process

Energy introduced (**EI**) into the system to make the transformation possible throughout its life cycle.

Example: Energy used to build the vehicle, feed the factory worker and the company accountant, transport, etc.



Raw materials or Energy that need to be transformed by the process, always with an efficiency lower than 100 %.

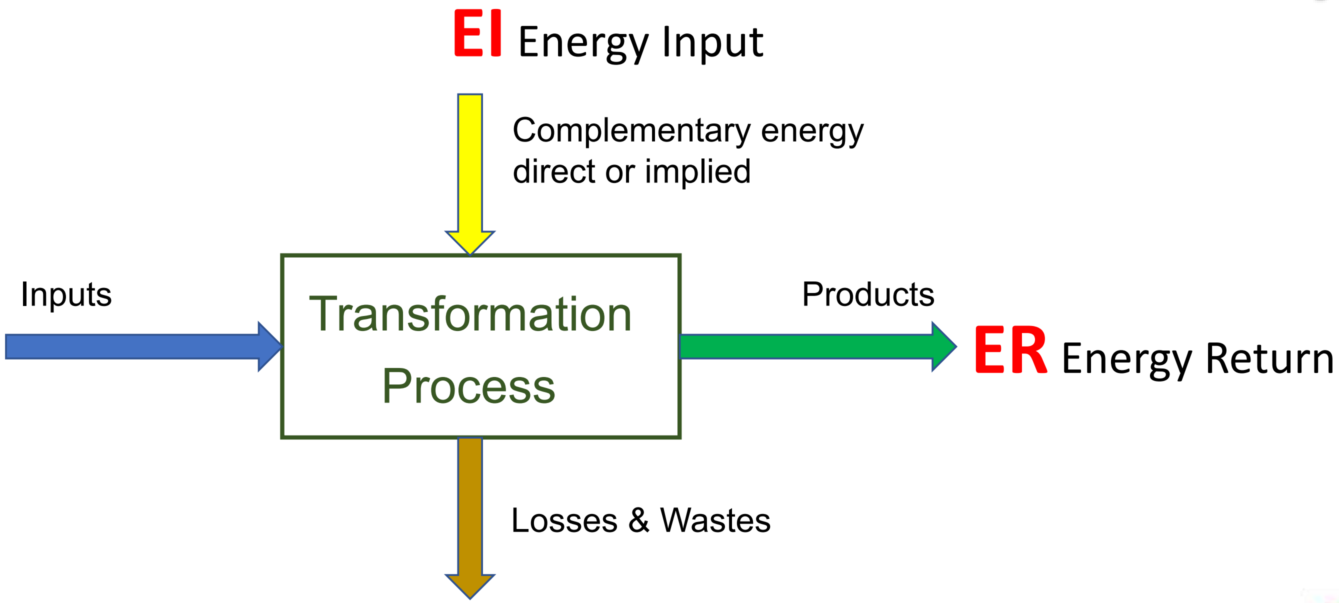
Example: Petrol used in a thermal engine.

Dissipated or stored at room temperature.
To recycle them (if possible), another process must be initiated.

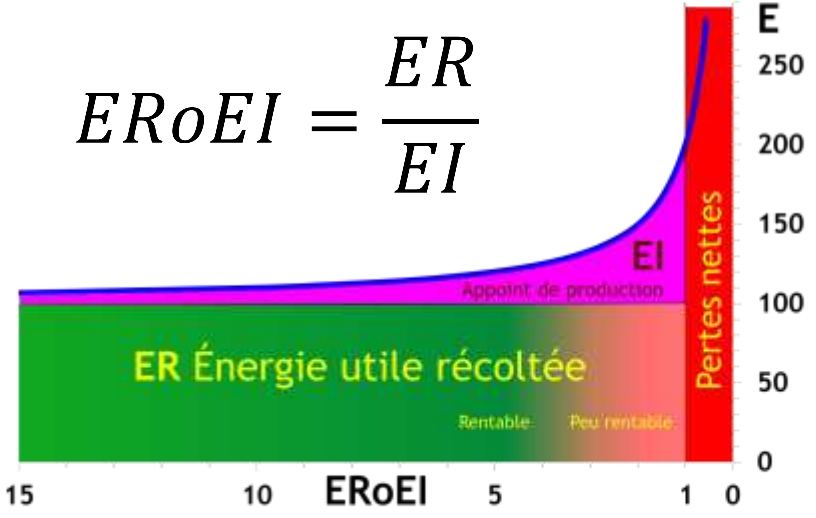
Useful Energy, Final Energy: (**ER**): Directly usable form, without further processing, actually transformed for the purpose of the process. Also called **exergy**, which expresses the maximum recoverable work.

Example: Mechanical energy that moves a vehicle.

Primary energy harvesting

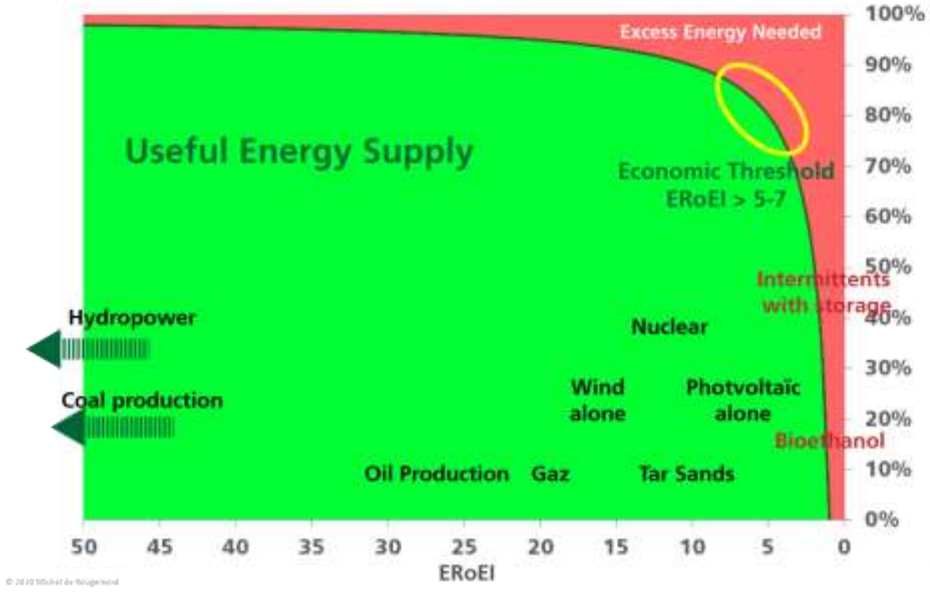


$$EROEI = \frac{ER}{EI}$$



If EI > ER, or ERoEI <= 1,
Then the process consumes more than it delivers, it is unsustainable because it requires input from an external source (subsidy).

Economic threshold: ERoEI >> 5 to 7



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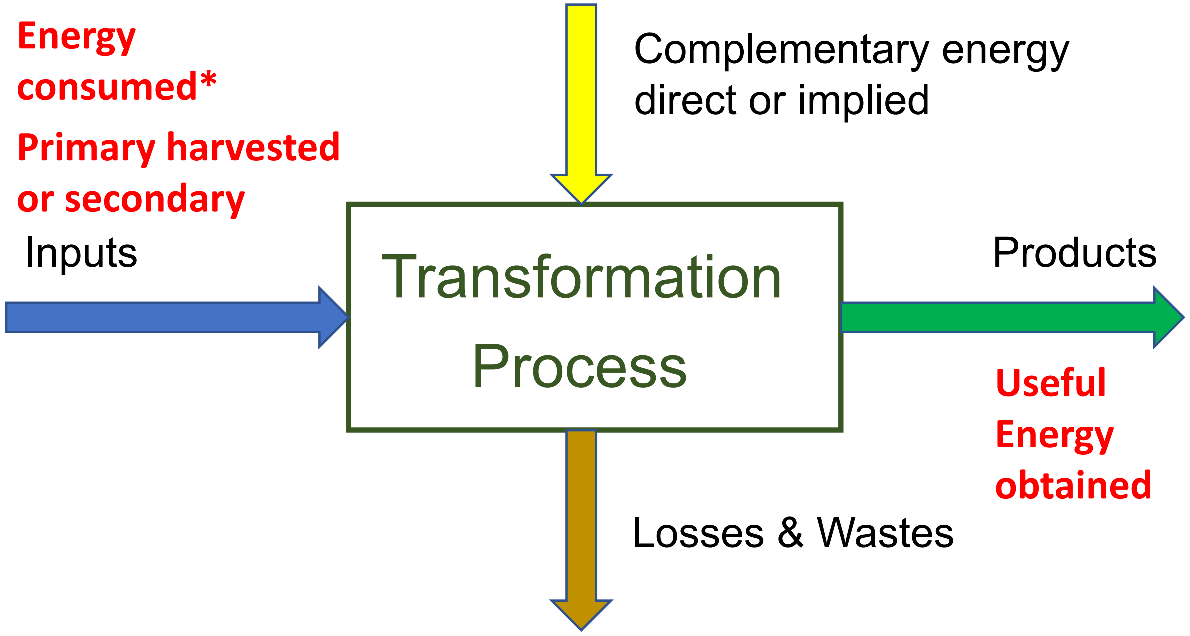
Efficiency, Yield



$$\eta = \frac{Useful\ Product}{Inputs\ used} = \frac{Energy\ obtained}{Energy\ consumed}$$

The efficiency of a thermal machine depends on the absolute temperature [K] of the source (upper temperature) and that of the energy sink (lower temperature), according to Carnot's law, valid for an isolated system:

$$\eta = 1 - \frac{T_{sink}}{T_{source}}$$

According to BP, a 'standard' thermal power plant has an energy efficiency of 40%. It takes 2.5 kWh of fuel to get 1 kWh of electricity.

The efficiency of a pumped storage station that stores energy by pumping water to higher ground is at best 80%.
It needs to consume 125 kWh to later feed 100 kWh back into the grid.
The difference of 25 kWh is dissipated at ambient temperature.

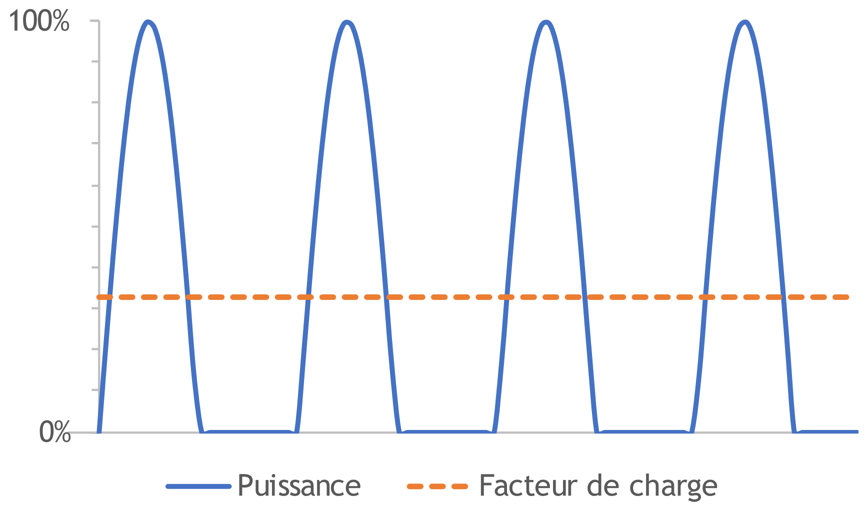
* Warning: not to be confused with the EI of ERoEI, only the inputs being processed are considered, not the complementary accessories.

Capacity factor

The Capacity Factor (CF) expresses the utilisation rate of a piece of technical equipment over a period of time (typically a year).

It is calculated as the ratio of the actual production to that which could have been achieved throughout the period if it had operated continuously at 100% of its rated capacity.

CF multiplied by 8760 expresses the number of equivalent hours that would have been worked in the year at 100% of the installed capacity. The value [100 - CF] is the idle rate of an equipment, its technical unemployment rate.



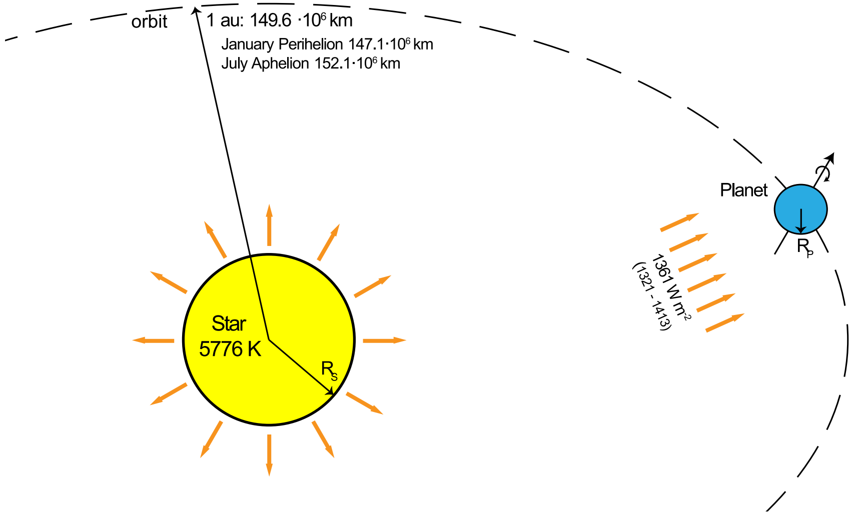
Typical CF values for power generation:

- Photovoltaïc module: in Switzerland 11%, in the Sahara 25 % ;
- Wind turbine éolienne: in Switzerland 20%, offshore in Denmark 40 % ;
- Run-of-river hydroelectric power station: in Switzerland 60 % ;
- Hydroelectric storage power plant in Switzerland : env. 20 % (pilotage);
- Pump-storage station < 25 % ;
- Nuclear plant: 80 to 90%, depending on maintenance and overhaul outages ;
- Thremal plant: from zero (emergency diesel) to 80 or 90 %, according to needs.

Solar irradiation and photovoltaics

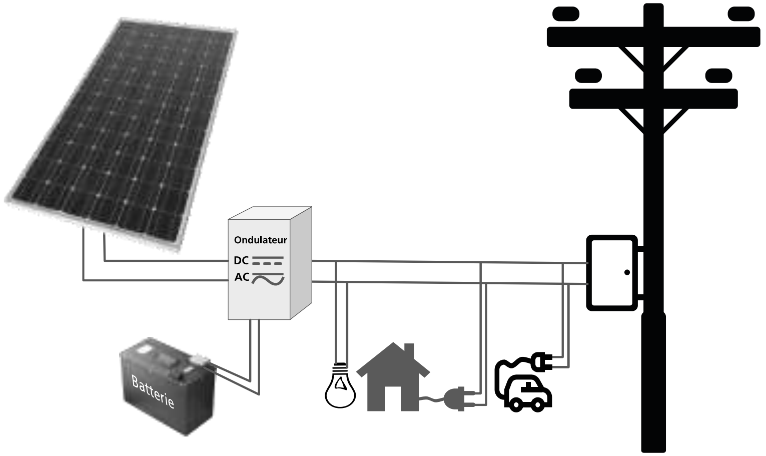
Solar irradiation :

At the edge of the Earth, before entering the atmosphere, 150 million km from the Sun, the solar irradiance (amazingly called the solar constant) is 1 361 W·m^{-2} (between1 413 at the perihelion, early January, and 1 321 at the aphelion, early July). Averaged over the year, taking into account the sphericity of the Earth and its rotation, the received irradiance is one quarter of this value, i.e., ~340 W·m^{-2}.
Measured on the ground, this radiation is attenuated by the atmospheric layer and its clouds. In Switzerland and at midday, the maximum irradiation reaches 1000 W·m^{-2}.



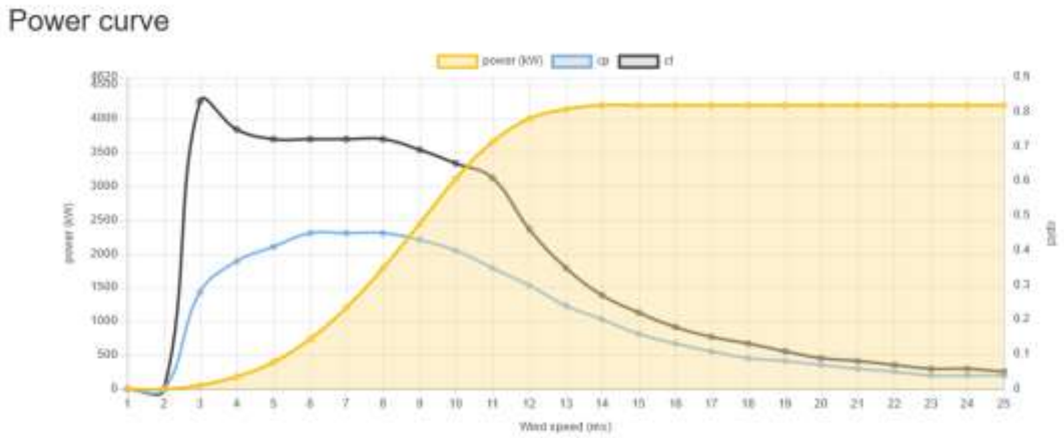
Photovoltaics (PV) :

Electricity generation using the ability of a material (e.g., silicon panel) to convert solar irradiation into electricity.
Under optimal conditions, at midday, a modern solar panel provides a power of 200 W·m^{-2} in the form of direct current and then, transformed by an inverter, as usable alternating current that can be fed into the grid. .
In reality, and also as a result of the cloud cover, a panel with a nominal capacity of 200 W_p will only supply about 22 useful watts on an annual average in Switzerland (CF = 11 %).

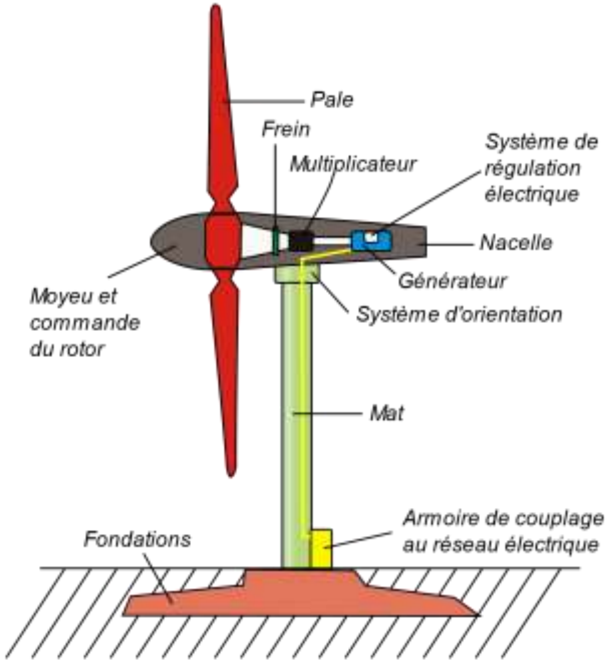


Wind power

Wind energy:
Transformation of the kinetic energy of the wind into electrical current.
According to Betz's law, a maximum of 16/27 (59.3 %) of the energy contained in the wind can be harvested.
The harvesting power is proportional to the cube of the wind speed.
A modern wind turbine has adjustable blades that allow the useful range of wind speed to be spread out.
Beyond a maximal threshold it must be feathered.
The turbine needs external energy to get started or to keep moving in calm weather (4-5% of the total energy it produces, or more if the blades have to be heated to prevent icing).



Yellow : power delivered (left scale)
Blue : Power coefficient = (Power produced / Power available in the wind)
Black : coefficient of thrust
Source : https ://en.wind-turbine-models.com/turbines/1183-enercon-e-126-ep4



Source : Wikipedia

Power curve of a wind turbine Enercon E-126 EP4

Rated Power:	4.2 MW
Rotor diameter:	127 m
Blade tip speed:	77 m/s, or 277 km/h
Total height:	163 to 210 m
Wind speed range:	3 à 34 m/s

MR's Blog

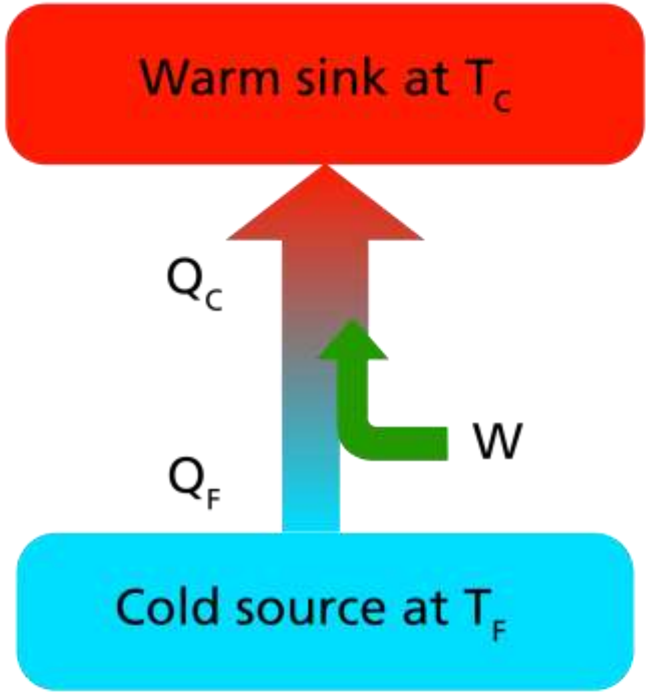
Heat Pumps

A thermal device that extracts energy from a cold source and returns it at a higher temperature.
To accomplish this feat, electrical energy must be supplied to a compressor.

Refrigerator or air conditioner: the cold source is the inside of the refrigerator cabinet or the room, the hot sink is the ambient air behind the fridge or in the street, in both cases near the appreciative cockroaches.

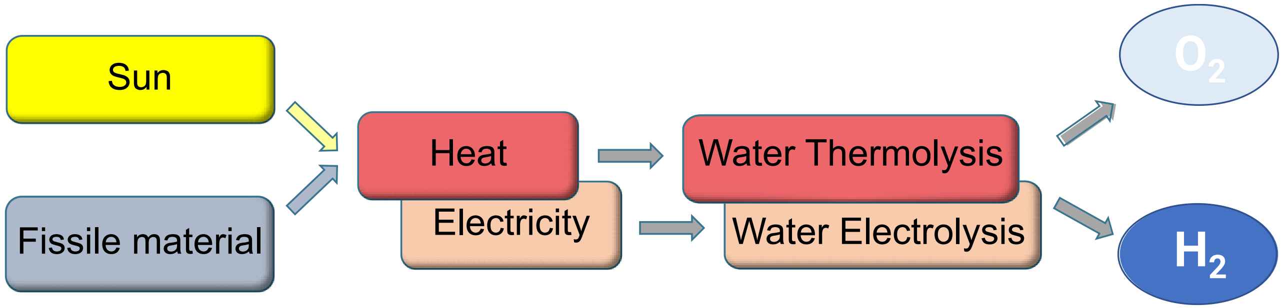
Heat pump: the cold source that evaporates a refrigerant is the ambient air outside; the air inside the house is the hot sink where this gas is condensed after it has been compressed (electric compressor).

Heat pumps are specified according to their Coefficient of Performance (COP) which is the quotient of the heat obtained by the electrical energy used. It is in the order of 3 to 4. They lose some of their efficiency in very cold weather and must be supplemented by direct electric heating.



$$COP = \frac{Q_C}{W_{el}}$$

Hydrogen



Hydrogen should be considered more as a chemical reagent (powerful reducer) than as an energy carrier.

It is no answer to the question of intermittent electricity storage.
(prohibitive capacity factor)

Production:

- Partial combustion of gas (methane),
  current and at very large industrial scale.
- Electrolysis of brine (by-product of chlorine and caustic soda)
  or of water, yield < 75%, little practiced.
- Thermolysis.
  Future with high temperature nuclear reactors.
  Challenges: oxygen separation, catalysis, yields.

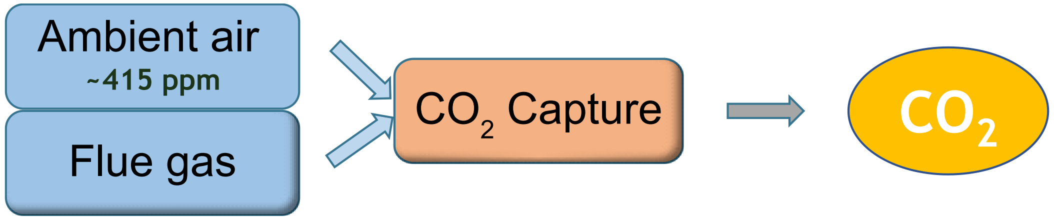
Characteristics :

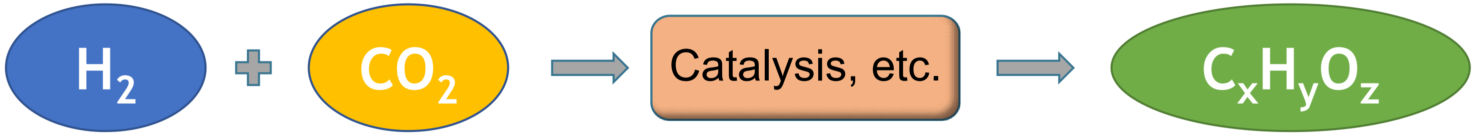
- Explosion between 4 and 75 % vol. in air,
  Very low minimum ignition energy.
- Combustion heat 120 MJ/kg.
- Density : 0.09 Kg/m^3 at ambient pressure, 42 Kg/m^3 at 700 bar,
  72 Kg/ m^3 as a liquid at −252,87 °C.
- Energy density in the liquid form 8 640 MJ/ m^3,
  4 times less than jet fuel.

Usage :

- Ammonia and nitrogen fertiliser synthesis
- Chemical reductions
- ~~Thermal~~ (turbines, fuel cells, etc.)
  an expensive aberration!
- Synthetic fuel production
  Challenges: energy efficiency and costs

Synthetic fuels





Hydrogen reduces CO_2 that is captured at the source or from ambient air (415 ppm)

Products: oxygenated hydrocarbons including methanol, formic acid and others.

Objective: to obtain a new **energy vector**...

- as **dense** as petrol or diesel
- to be used in **existing** thermal engines
- To **propel** cars, trucks, trains, ships, planes
- **without new issue** of logistical or technical nature.

Well known industrial process:

- Fischer-Tropsch, 1923

Problem :

- Source, yields and cost of hydrogen

Challenges:

- Catalytical process
- Energy efficiencies
- Costs

Biomass and biofuels

Photosynthesis is at the service of life,

not of energy production.

Photosynthesis is extremely powerful in the spring or during the growth of young shoots, but it is seasonal and yields only one crop per year (or two for some crops in the tropics).

Biomass example:
Approximately 30 tonnes per year of dry wood can be harvested from one hectare of highly productive forest.

With a combustion heat of 5 $kWh \cdot kg^{-1}$, it is equivalent to a power of 1.74 $W_{th} \cdot m^{-2}$ that is deployed.
whereas photovoltaics with a CF of 11% harvest an annual average of 22 $W \cdot m^{-2}$ as directly useful electricity..

The situation for bioethanol and biofuels is worse.

These fuels are only of interest because they are liquid, easy to handle and store, and can be used in conventional thermal engines and turbines.

Energy densities

Depending on their nature, energy carriers have a different mass or volume density, which is important for their storage and transport.

Energy content	kWh/unit	unit
Petrol SP95	13	kg
	10	litre
Natural gas (methane)	10.6	m^3
	14.8	kg
Hydrogen	3.54	m^3
	39.4	kg
Coal (anthracite)	7.5	kg
Wood and dry wood waste	5	kg
Enriched uranium at 3,5% ^{235}U	960 000	kg
Lead Battery	0.041	kg
Li-ion Battery	0.128	kg

Territorial footprint

The area occupied by a power plant depends on the installed capacity [MW_{el}] and the technology used.
In addition, the annual production per unit area [$kWh \cdot m^{-2} \cdot yr^{-1}$] depends on the capacity factor of this technology at the location where it is installed.

Area mobilized for1 MW	m^2/MW	Production $kWh \cdot m^{-2} \cdot yr^{-1}$
1358 Horses developing 736 W each Fodder 12 kg/day, prod. 20 000 kg/ha/yr	3 000 000	0.96
Photovoltaïcs (200 W_p/m^2)	5 000	193
Wind (turbines with 3 MW_p, diameter 120 m)	21 000	83
Run-of-river hydropower (Rheinfelden, 100 MWe)	700	7 500
Storage hydro (Grande Dixence, Bieudron 1269 MW_e) Reservoir 3,65 km^2 Catchment area 360 km^2	2 880 284 000	550 5.5
Nucleare for one 1 Reactor alone (Leibstadt, 1233 MW_e)	170	44 000

's Blog
On & Off the Line

ENERGY PRINCIPLES

Principles must be respected so as to make things possible, and also to avoid disasters.

These are not moral injunctions but practical ones, although it is amoral not to respect them deliberately.

DEFINITIONS

CONSEQUENCES

Thermodynamics

The four principles of thermodynamics must be respected.

0.- Equilibrium:	If a system A is in equilibrium with B and B is also in equilibrium with C, then A is in equilibrium with C.	Allow to measure the temperature with a thermometer.
1.- Conservation:	Energy is conserved. The energy of an isolated system does not change.	If it does change, it must be due to an external source or sink.
2.- Disorder:	The level of disorder of an isolated system (its entropy) can only increase. The entropy is maximal when the system is in equilibrium.	Bringing order requires an external energy input or will cause more disorder elsewhere in the system.
3.- Absolute zero:	The entropy of a pure substance is zero at absolute zero temperature (T= 0 Kelvin or -273.15 °C, this is an unattainable absolute).	The interspace is at 2.7 K. No measurement is possible below that.

1. **Energy does not renew itself.**

   Except for life, nothing is renewable.

   What gets repeated is the opposite of new.

   Energy is harvested where it is accumulated or where it passes through.

2. **No energy conversion without losses.**

   The losses are dissipated in the form of heat in the environment surrounding the transformation facility.

   Ultimately, these losses are dissipated into the interplanetary space.

3. A country's power supply.

Must be provided at all times and without interruption by

- local harvesting of primary energy,
- local transformation of secondary energy,
- supplemented by imports to meet instantaneous market demand, or exports in case of production surpluses.

4. Electric current cannot be stored as such.

If it is available in excess of market demand (the "grid draw" by all users), it must either be exported as is, or transformed into a storable form, or no longer produced, or the demand must be modified.

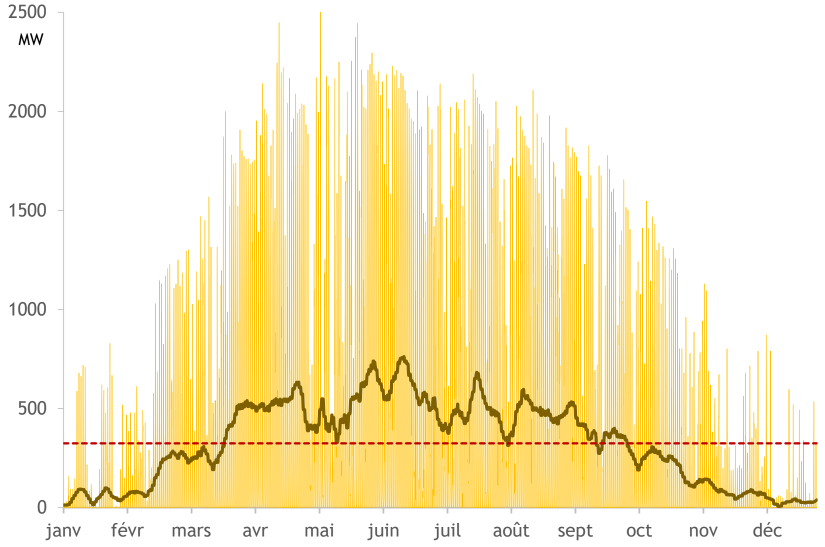
The storage of electricity requires 6 steps:

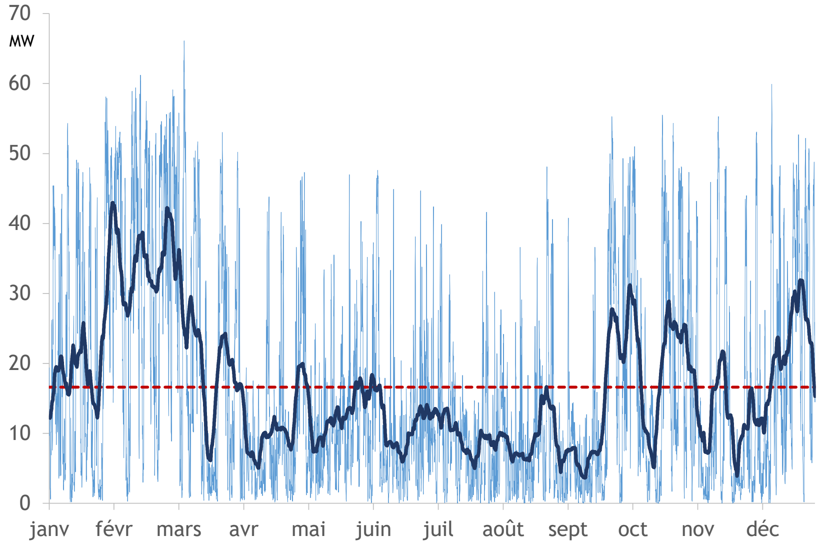
(1) production of electric current,
(2) transport to the charging facility,
(3) transformation into storable form,
(4) storage,
(5) transformation into electric current,
(6) transport to the user of this current.

The capacity factor (CF) of such a system is at best that of the first stage.

5. Intermittent and fatal electricity generation.

Photovoltaic or wind power can never meet demand without additional short and long term (seasonal) storage, as well as adapted transport lines.





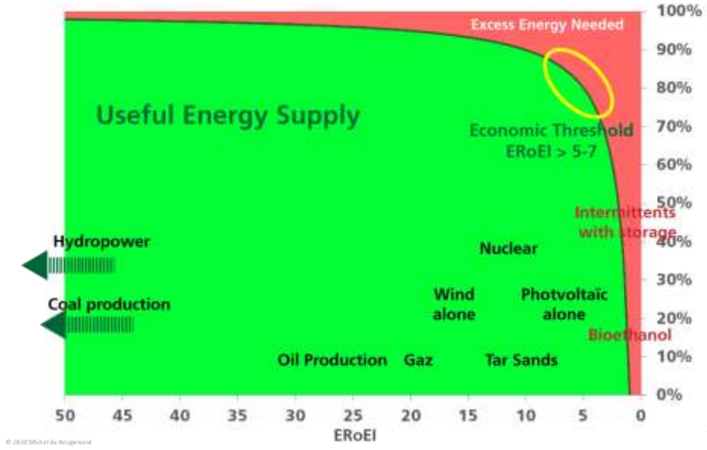
Photovoltaic production in Switzerland in 2021 (left) and wind production in 2020 (right).
The dark curve is the 7-day smoothed average. The red dotted line is the load factor CF.
Source : energy-charts.info, OFEN.

6. ERoEI: while ER is relatively straightforward to define, this is not the case for EI.

A comparison of energy, material or financial balances between different systems **must include all their components** over their entire life (life cycle analysis):

- Construction;
- Operations, including necessary processing, storage, and associated losses;
- Waste treatment;
- Compensation for negative externalities or credit for positive ones;
- Dismantling of installations that have become obsolete.

7. EroEI >> 1



This is the condition for harvesting of a primary energy source to ensure a general energy supply;
otherwise, another primary or secondary source must be hired on a long-term basis to exploit this primary source, which is a subsidy that hides an impossible sustainability.

Another way of understanding this imperative is that
the payback time of the energy consumed by the energy produced must be less than the lifetime of the installation;
otherwise, more will have been spent than obtained.

Example: Supplying an alpine hut with photovoltaic solar energy can be done with such a subsidy from elsewhere.
It is however not possible to supply an entire economy that would exhaust itself consuming more energy than it can harvest.

8. Rated capacity and load factor

The rated capacity to be installed to satisfy a demand **is inversely proportional to the capacity factor** characterising the technology used at the location where it is installed.

Assumption:
In 2050, or after decarbonisation, the demand for electricity will be 90 TWh/a, of which 40 TWh/a may be supplied by hydro.
For the remaining 50 TWh/a, capacity requirements would be:

- **52** GW_p PV, solar panels with a CF = 11%, i.e., 14 600 soccer fields with 200 W/m^2 panels, or
- **29** GW_p wind power with a CF = 20%, i.e., 10,000 3 MW wind turbines, one every 2 km throughout the country, or
- **9.5** GW_{el} gas CCGT with CF= 60%, i.e., 38 plants of 250 MW, identical to the Birr (AG) reserve plant, or
- **6.7** GW_{el} nuclear with CF = 85%, i.e., 4 plants of 1.65 GW, occupying a total of 1.2 km^2 of territory.

9. CF of an energy-consuming facility.

The capacity factor of one facility consuming the output of another will be **equal to or less than** that of the source.

This applies to power storage facilities in whatever form.

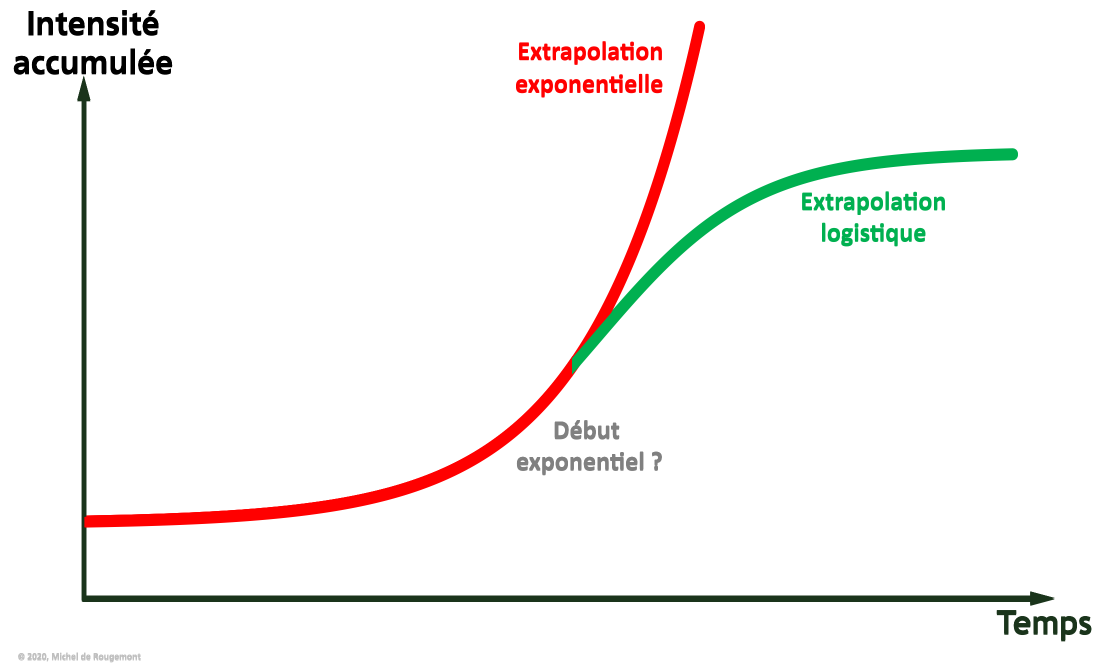
Example: *An electrolyser producing hydrogen with electricity supplied by a wind farm with a CF of 20% will also have a utilisation of 20% of its rated capacity (which must be as high as that of the wind turbines).*

In other words, 4 times more electrolysers would have to be built than would be normal (having a "normal" target of CF = 80%).

10. Exponential.

Nothing is exponential because everything ends after the available material and energy resources have been consumed.

The evolution of a phenomenon, explosion or demography, which the impatient, the worried and the alarmist declare exponential, ends like a logistic function (in the form of a sigmoid).



11. Facts are stubborn.

MR's Blog
On & Off the Line

CONSEQUENCES

Consequences must be drawn from facts and principles

DEFINITIONS

PRINCIPLES

History

Energy density has improved as energy expenditure has been entrusted to draught animals, then to more efficient machines using more powerful vectors.

This undeniable path of progress is now being broken by the promotion of so-called renewable energies which are not so, and which, in any system and in any proportion, however small

- **do not meet demand at all times,**
- **reduce the efficiency of power generation,**
- **increase costs,**
- **multiply capital requirements,**
- **destabilise the grid,**
- **impose a larger environmental footprint.**

Multiple studies are dedicated to reinforcing, proving and promoting national energy strategies; most of them are flawed, biased and fraught with conflicts of interest; they take little or no account of the consequences of the intermittency of so-called renewable sources.

The statement highlighted above is the result of thoughtful consideration encompassing all these issues (Rougemont, 2022).

Reference values

- A country's energy supply
  must be dictated by the demand of its economy,
  both annual and instantaneous in the case of electricity.

  Production shall not dictate demand,
  although special conditions may induce some of that demand to adjust to availability.

- Unmet demand leads to losses:
  economic, competitive and reputational.

- Intermittent and fatal production such as photovoltaic or wind power cannot meet demand without storage and transmission systems, with the corresponding losses and additional costs and wastes.

- It is professionally negligent to consider only the first stage of production, isolated from the others.

ERoEI (ter) and the economy

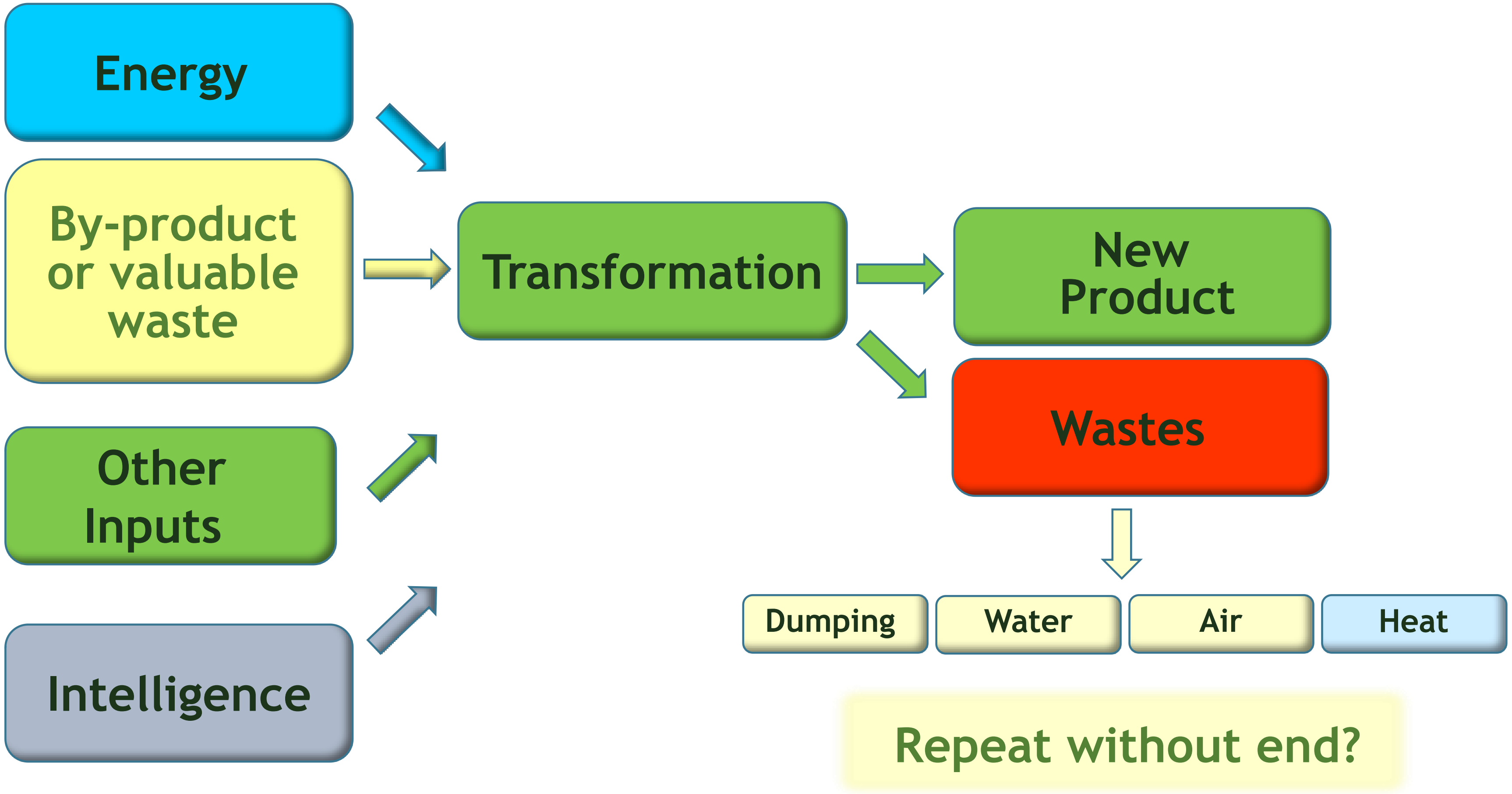
- It is not enough for ERoEI to be greater than unity.
  The efficiencies involved and the constraints on resource use mean that
  ERoEI needs to be at least 5 to 7
  for primary energy harvesting to be economically (and therefore socially) affordable.
- It should not be forgotten that EI is itself dependent on the way it is obtained.
- The lower the ERoEI, the higher the share of GDP (Gross Domestic Product, a measure of produced wealth) that must be devoted to energy supply.
  Nobody, except the yellow waistcoats, knows what the maximum tolerable limit is.
- The greed of the players in this sector explains their interest in lowering this ERoEI (= diminishing efficiencies).
- However, the purpose of a human society cannot be limited to feeding, clothing, caring for oneself, avoiding pollution and transforming energy just to that end.
  More energy is needed for the pursuit of more important and ambitious, more human goals.
- The scientific and technical literature on ERoEI is particularly scarce
  (Mearns, 2016), (Weißbach et al., 2013), (Ferroni & Hopkirk, 2016).

Technology substitution *(Energiewende)*

Having a poor capacity factor and being non-pilotable, a low-availability technology is not suitable to replace a high-availability one, regardless of its isolated individual cost.

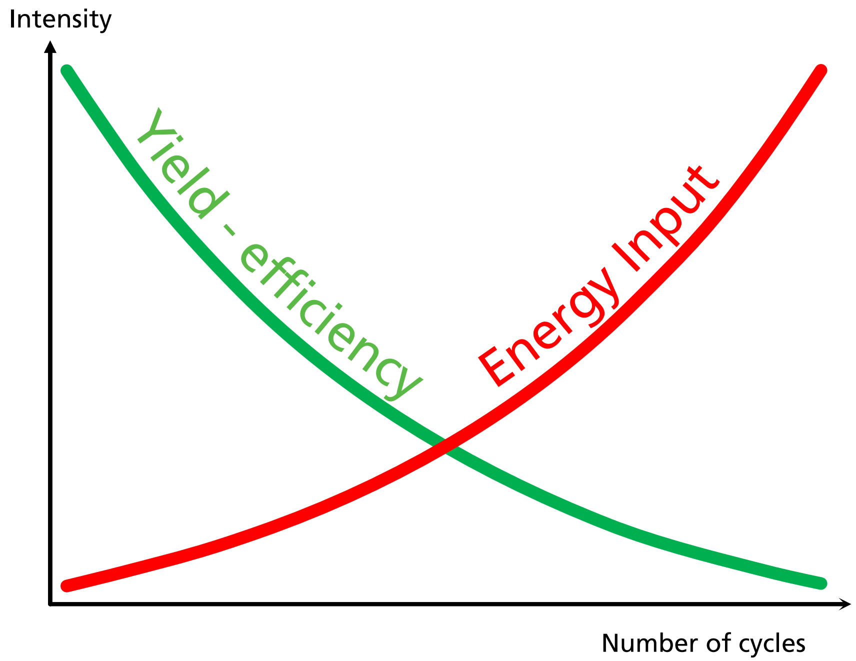
Recycling

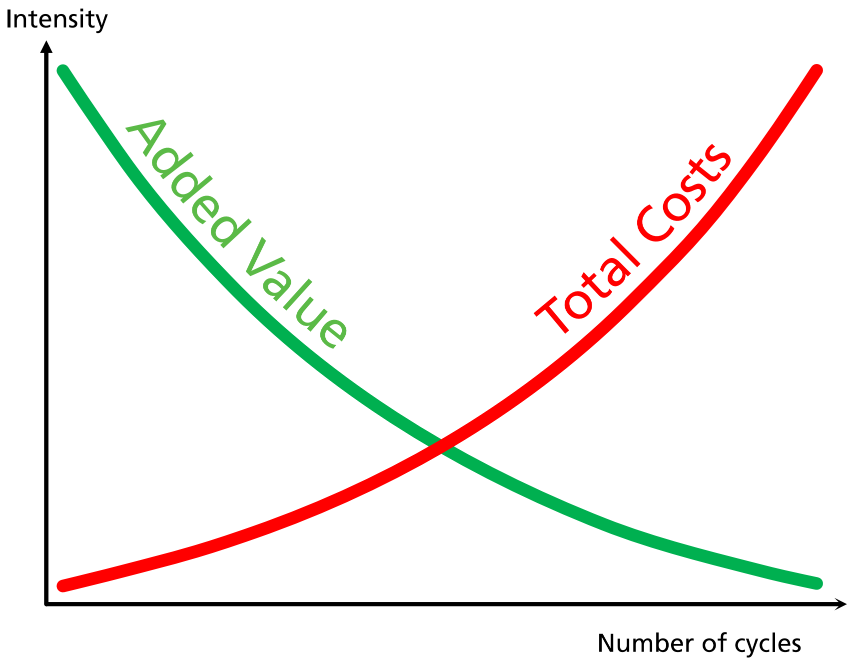
Not everything can be recycled, and the yields multiply from stage to stage to approach zero.



Limits to recycling

Any recycling operation reaches its limits when
the human, material and energy resources required
exceed the energy, economic or social value of the recycled material obtained.





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Investments and Capital Requirements

- Capital requirements follow the same law as the nominal capacity,
  they are inversely proportional to the load factor.
  In addition, lifetimes are not the same for different technologies and must be considered when comparing them.
- A comparison of investments and costs is only valid for a similar scope:
  satisfying demand at all times and over a common period of time, for example a century.
- The table on the next slide gives a rough, but realistic and comparable estimate of the investments needed to supply an additional 50 TWh/a of electricity (as per the example given on slide 28) by one of the possible technologies.
  In summary:

Industrial Solar	230%	14 600 soccer fields
Domestic Solar	460%	
Wind	150%	10 000 turbines with 3 MW_p
Gas turbine	320%	38 times Birr (250 $MW_{él}$)
Nuclear	100%	4 reactors with 1.65 $MW_{él}$, 1.2 km^2

Comparable Costs

	Rated Capacity GW	Specific capital cost Fr/kWe	Total Investment Mrd Fr		Investment over one century Mrd Fr
Industrial Photovoltaïc			**151**		**317**
Modules	52	1000	52	Life span 25 to 30 years	156
Storage - Restitution - Transport	52	1500	78	Life span 80 years	98
Dismantelment and waste management		400	21		63
Domestic, Roof Photovoltaïc			**255**		**629**
Modules	52	3000	156	Life span 25 to 30 years	468
Storage - Restitution - Transport	52	1500	78	Life span 80 years	98
Dismantelment and waste management		400	21		63
Wind			**91**		**203**
Turbines**	27	1500	40	Life span 25 to 30 years	120
Storage - Restitution - Transport	27	1500	40	Life span 80 years	50
Dismantelment and waste management		400	11		33
Gas (combined cycle CCGT)			**176**	Life span 40 years	**440**
Immobilised Capital	9.5	630	6		15
Purchase of gas (Currently at 50 Fr/MWh, with 60% yield)			168	**4,2 Mrd Fr/yr**	420
Dismantelment and waste management		210	2		5
Nuclear			**82**		**137**
Immobilised Capital	6.7	5000	34	Life span >60 years	57
Purchase of fissile material			18	^{235}U à 6 Fr/MWh	30
Dismantelment and waste management			30	10 Fr/MWh paid to funds	50

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Necessary trade-offs

False pretenses

The production of coal and gas-fired power stations in Germany is the cover-up for "renewables", whose congenital defects must be shamefully concealed.

Factors for decision

- The comparative performance of the technologies involved is undeniable in the eyes of honest people who have no conflicts of interest.
- The choice of investments to be made in the very long term must also be justified by the environmental or social value that can be attributed to one solution rather than another. Valid indicators on this subject are still lacking.
- Counting CO_2 everywhere and for everything is not adequate, since, ultimately, no more will be emitted.
- Qualitative or ideological criteria, or political and emotional conjectures, cannot justify gigantic investments.
- The figures in the previous table only concern electricity supply. To this, all changes in consumption should be added which are also enormous.

Final Consideration

The magnitude of the task is such that even a wealthy country cannot afford the luxury of any inefficiency, which would surely lead to its ruin.

Contact

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